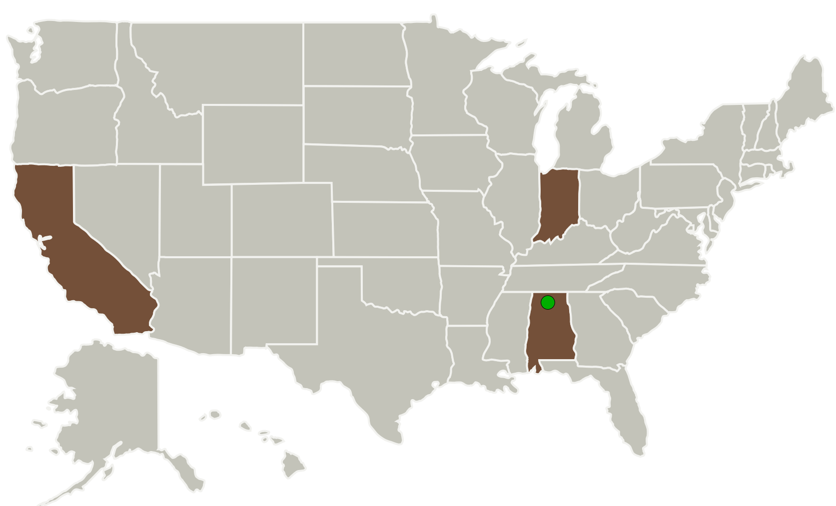
Multiphysics Framework for Prediction of Dynamic Instability in Liquid Rocket Engines, Phase I

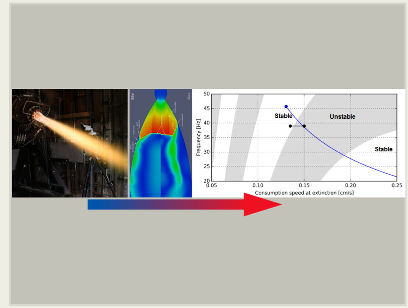
Completed Technology Project (2017 - 2018)

Project Introduction

Mitigation of dynamic combustion instability is one of the most difficult engineering challenges facing NASA and industry in the development of new continuous-flow combustion systems such as the combustion chambers in liquid-fueled rocket engines (LREs). Combustion instabilities are spontaneous, self-sustaining oscillations that tie the combustor acoustics to the combustion reaction itself. These oscillations can lead to a wide range of problems from off-design performance to catastrophic failure. Efforts to predict instabilities at design-time is hindered by the complex, multi-physics nature of the acoustics and chemistry, typically requiring multiple iterations of time and resource intensive system prototyping. The proposed Phase I STTR project aims to develop a simulation framework that will enable accurate, design-time prediction of instabilities. This framework will leverage the capabilities of Loci/CHEM for massively parallel, multi-physics flow simulations to generate low-order, independent models of combustion and acoustic response to perturbations. By solving for simultaneous solutions of these low-order perturbation models, it will be possible to numerically map the acoustic modes of the system to their stability characteristics, providing a means to predict instability. Phase I will develop critical additions to Loci/CHEM's combustion modeling capabilities, develop the appropriate acoustic models, develop a test plan for experimental validation of the combustion model, and conclude with a proof-of-concept demonstration of the full framework. In Phase II, an experimental campaign will be carried out to validate the combustion modeling tools developed in Phase I and augment the simulation framework with multi-phase modeling appropriate for full-scale LRE combustion chambers.

Primary U.S. Work Locations and Key Partners





Multiphysics Framework for Prediction of Dynamic Instability in Liquid Rocket Engines, Phase I Briefing Chart Image

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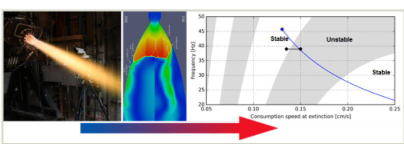
Organizations Performing Work	Role	Type	Location
ATA Engineering, Inc.	Lead Organization	Industry	San Diego, California
Marshall Space Flight Center(MSFC)	Supporting Organization	NASA Center	Huntsville, Alabama
Purdue University-Main Campus	Supporting Organization	Academia	West Lafayette, Indiana

Primary U.S. Work Locations	
Alabama	California
Indiana	

Images



Briefing Chart Image
Multiphysics Framework for Prediction of Dynamic Instability in Liquid Rocket Engines, Phase I Briefing Chart Image
(https://techport.nasa.gov/image/133215)

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

ATA Engineering, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

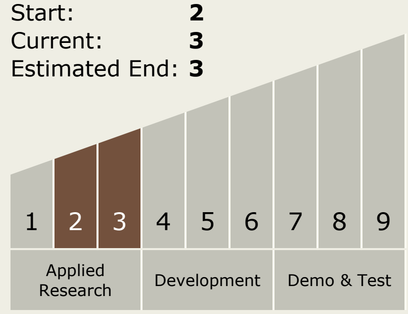
Carlos Torrez

Principal Investigator:

Zachary Labry

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX01 Propulsion Systems
  └ TX01.1 Chemical Space Propulsion
    └ TX01.1.3 Cryogenic

Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System